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TITLE: Movement detection system

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ABSTRACT:

A movement detection system having an ultrasonic transmitter (1) sending periodic bursts of ultrasonic signals and a receiver (2) receiving a signal containing components resulting from reflection of the transmitted signal from objects. A demodulator circuit (8) effects a phase comparison between the

transmitted and the filtered reflected signal to provide a reference signal.
The reference signal is processed (9) to select Doppler components, and
information from the end of the signal period and possibly also the beginning
of the signal period is suppressed (10) so that the duration of information in
the reference signal is limited. After rectification (12) and integration (13)
the information from successive reference signals is compared by means of a
sample-and-hold circuit (15) and a comparator (14) and the resulting difference
used to control an alarm. <IMAGE>

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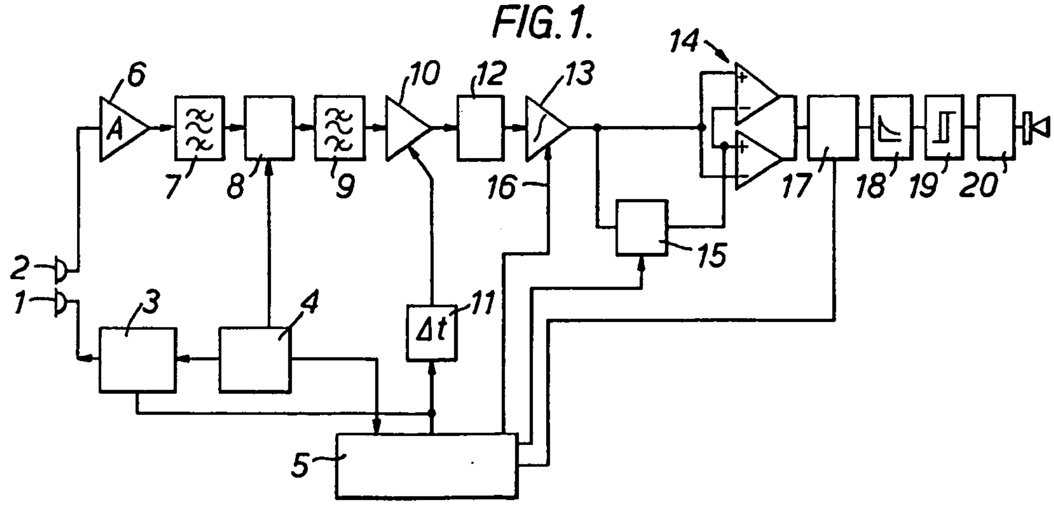
(54) Movement detection system

(57) A movement detection system having an ultrasonic transmitter (1) sending periodic bursts of ultrasonic signals and a receiver (2) receiving a signal containing components resulting from reflection of the transmitted signal from objects. A demodulator circuit (8) effects a phase comparison between the transmitted and the filtered reflected signal to provide a reference signal. The reference signal is processed (9) to select Doppler components, and information from the end of the signal period and possibly also the beginning of the signal period is suppressed (10) so that the duration of information in the reference signal is limited. After rectification (12) and integration (13) the information from successive reference signals is compared by means of a sample-and-hold circuit (15) and a comparator (14) and the resulting difference used to control an alarm.

FIG. 1.



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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

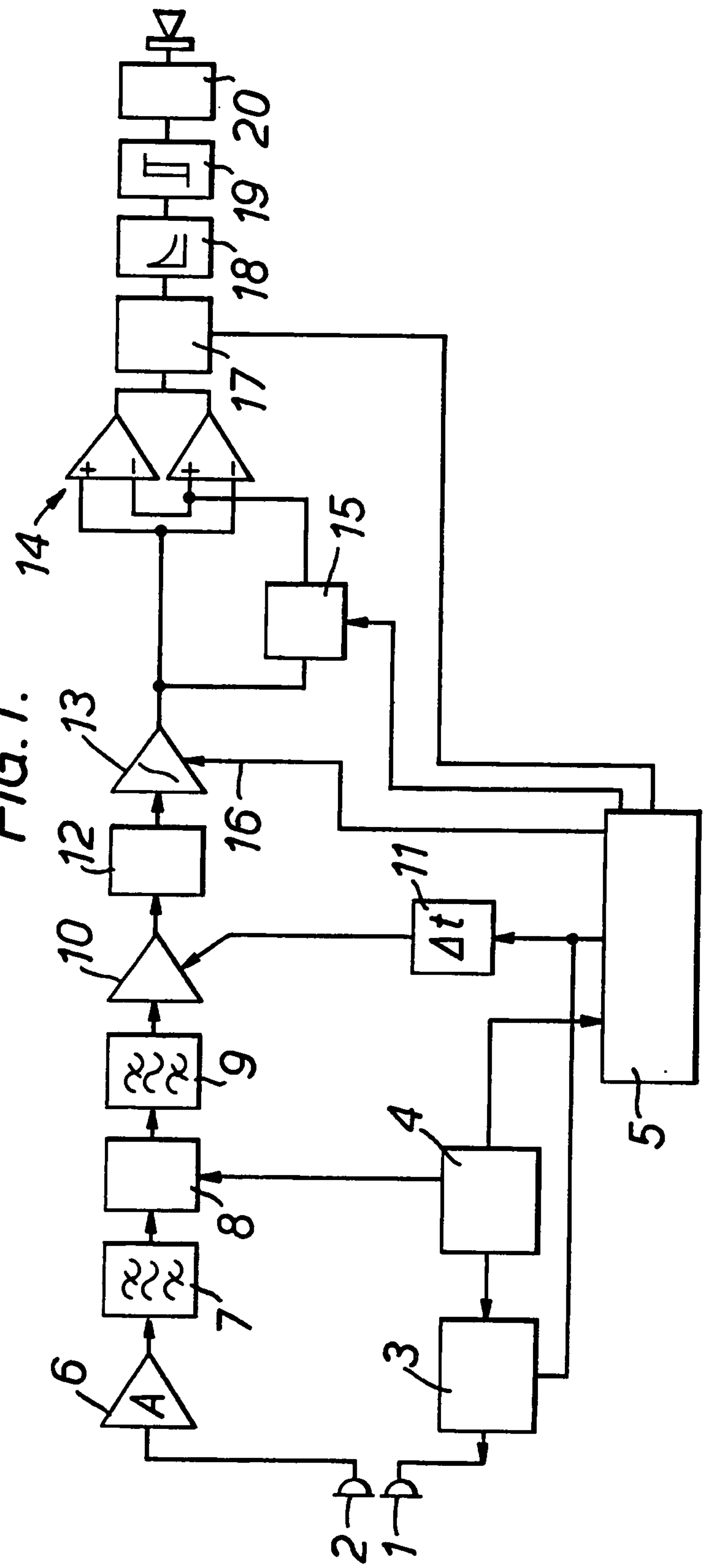
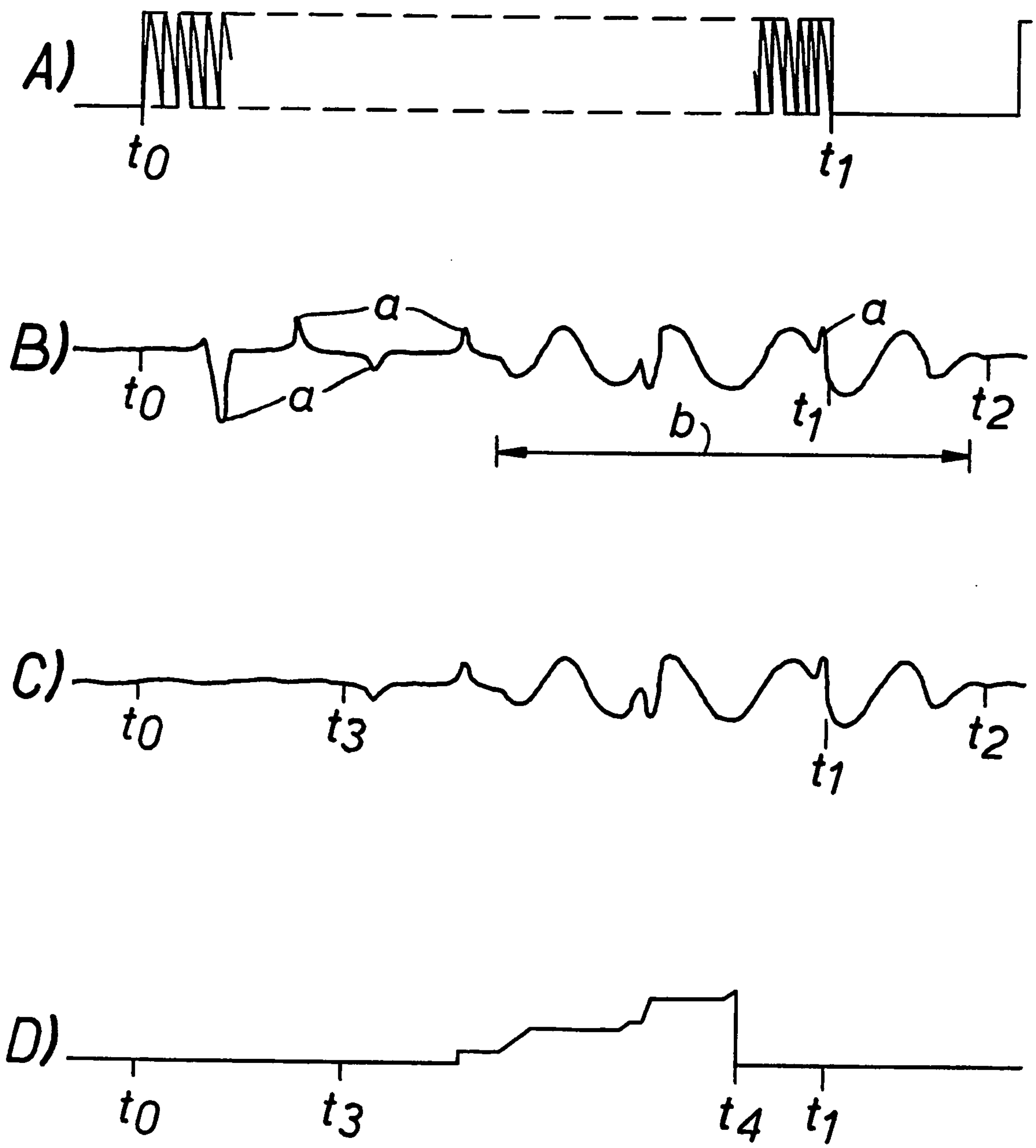


FIG. 1.

FIG. 2.



SPECIFICATION

Movement detection system

This invention relates to a movement dection system.

Movement dection systems have many applications. For example they can be used as intruder detectors and burglar alarms on commercial, industrial and domestic premises and in cars. They can also be used for the detection of the entry of objects or personnel into areas to which entry is restricted, either for security reasons or for safety reasons.

A number of movement detector systems based on ultrasonic techniques have been proposed and used. Such use has been limited to the safeguarding of buildings or of other enclosed areas, for example a saloon car, the walls surrounding the area forming a barrier for the ultra sound and effectively limiting the range thereof. It would be useful to be able to use ultrasonic detection systems in the safeguarding of a confined area that is not bounded by walls, and the present invention seeks to solve the problem of providing such a system.

According to the invention a movement detection system comprises an ultrasonic transmitter, means for driving the transmitter to provide a series of pulses of ultra sound, an ultrasonic receiver positioned to receive reflected signals each being generated by impingement of a transmitted pulse upon objects lying within the beam area of the transmitted pulses, means to compare each transmitted pulse with the resulting reflected signal to provide a signal representative of phase differences between the two, means for limiting the duration of each representative signal so that this terminates before the end of the period which corresponds to the period of receipt of the reflected signal and means for utilising the representative signal to provide an output signal.

In use, a series of pulses of ultra sound is transmitted into the area where movement detection is required. The receiver will, for each transmitted pulse, receive an essentially continuous ultra sound signal reflected from all objects within the beam area of the transmitted pulse and will produce an electrical signal derived therefrom. By comparing the derived signal with the pulse-generating signal a signal representative of phase difference between the two will be generated. Each stationary object that is present in the beam area will provide a reflection to the receiver and the representative signal will then include an amplitude change indicative of the presence of that stationary object. However, in the absence of any moving object the amplitude curve of the representative signal from one pulse to the next will be identical. If between the scanning of consecutive pulses there is movement of an object, then the representative signal during the time of the second pulse will show differences in amplitude from that during the time of the first pulse and this difference can be detected and utilised to provide a signal indicative of movement within the beam area. Limiting of the area within which movement is detected, which is the objective of the invention, is achieved by terminating [illegible] sentative signal before the end of the period which corresponds to the period of receipt of the reflected signal. Reflections from objects closer to the transmitter and receiver are received earlier than reflections from objects that are more distant therefrom. Thus, by early termination of the representative signal the signal can be controlled so that it only contains information representative of objects lying within a given range.

The invention thus provides a detector capable of safeguarding an unbounded area. In one particular application the detector may be utilised as an anti-theft device in an open-top sports car, the range being set so that movement within the car will be detected, but movement outside the car, for example on the adjacent pavement or roadway, will not cause operation of the system.

There are a number of different ways in which the representative signals can be utilised to provide an output signal indicative of movement. Movement within the detection range causes a change in the amplitude curve of the representative signal from one pulse period to the next. In order to compare the representative signal during one pulse period with that in a subsequent pulse period some form of memory is required and this could, for example be digital memory or a delay line. However, such forms of memory are unnecessarily complicated and expensive for many applications and preferably each representative signal is rectified and integrated, the resultant voltage being stored in a sample and hold circuit. A comparison is then made between the voltage currently stored in the sample and hold circuit and the voltage derived from the next representative signal, the sample and hold circuit then being updated with the voltage from that next signal. If the compared voltages differ by a preset amount this indicates movement by a body of significant size within the given range and an output signal is produced which can be used to operate a visible and/or audible alarm. For practical puposes the system would probably be too sensitive if a single occurrence of voltage difference were to initiate an alarm signal. Accordingly it is desirable to include means ensuring that the alarm is only triggered when a preset number of voltage difference indications occur within a given period.

Limiting the duration of each representative signal may conveniently be effected by limiting the duration of that signal itself, with the transmitted pulse and reflected signal being compared during the whole of the transmitted pulse period. Alternatively the transmitted pulse and reflected signal may be compared only during a period which terminates before the end of the transmitted pulse period, so resulting in similar termination of the representative signal.

Desirably the duration of the representative signal is also limited by commencing the signal after the start of the period which corresponds to the period of receipt of the reflected signal. In this way high amplitude components in the representative signal due to reflection from objects very close to the transmitter and receiver are ignored. There may [illegible]r of such high amplitude

components saturating the system and so having a detrimental effect on sensitivity to relatively weak signals from more distant objects. Late commencement of the representative signal may also be an advantage when the area to be scanned is remote, as moving objects in closer proximity to the transmitter and receiver will not then affect the representative signal and those objects are thus ignored.

In order that the invention may be better understood a specific embodiment of a movement detection system in accordance therewith will now be described in more detail, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a block diagram of a detection system; and

Figure 2 illustrates example wave forms that may be present in the system.

Referring now to Figure the system includes an ultrasonic transmitter 1 and an ultrasonic receiver 2 mounted adjacent to the transmitter. The two transducers have as wide a beam width as possible in order to scan as wide an area as possible. Obviously, however, if large areas are to be protected then a plurality of suitably positioned systems may be used.

The transmitter is driven through an amplifier 3 by an ultrasonic-frequency oscillator 4. The output from the oscillator is gated in the amplifier 3 by a sequencing circuit 5 to provide bursts of ultrasonic signals (A in Figure 2) to drive the transmitter. The circuit also controls the sequence of events in other parts of the circuit.

During and after transmissions of each pulse from time t_0 to t_1 a signal arrives at the receiving transducer 2, the signal containing components resulting from reflections from objects within the maximum range of the system together with noise in other audio and ultrasonic frequencies. This noise, which may have been produced mechanically, is able to pass through the receiving transducer either because of spurious resonance or simply because of the intensity of the noise. The signal from the receiving transducer is amplified by amplifier 6 and is then filtered by a band-pass filter 7 to remove the noise and leave only the signal containing the reflection information. This signal is fed to a double balanced demodulator circuit 8 which is also fed by a reference signal from the transmitter oscillator 4. The demodulator circuit effects a continuous phase comparison between the signal from the filter 7 and the reference signal and provides an output voltage that contains a high frequency component at twice the frequency of the reference signal and a DC and low frequency component that is proportional to the cosine of the phase difference between the reflected and reference signals. This voltage is applied to a band-pass filter 9 which eliminates the high frequency and DC component and provides at the input to an amplifier 10 a signal consisting of the doppler frequencies resulting from the movement of bodies in the detection zone at a velocity higher than some threshold determined partly by the lower cut-off frequency of the band-pass filter 9 and partly by the angle between the wave motion.

A typical filtered output from the demodulator 8 is shown at B in Figure 2. It consists of transients such as *a* due to the onset of reflections from stationary objects (which transients will be the same from pulse to pulse) and sinusoidally varying voltages such as in region *b* due to moving objects causing a dopple shift in the reflected signal and resulting in continuous phase change in that signal. These varying voltages will change from pulse to pulse, and can of course occur in any time region of the demodulator output signal. The output is thus a signal representative of changing phase differences between the reflected and the reference signals, and is of duration from t_0 to t_2, longer than the duration of the transmitted pulse. The time t_2 is the time at which the reflected signal has died away to an insignificant level. The succeeding new pulse should not be transmitted until after this time.

As already stated the signal from filter 9 is received by amplifier 10. The sequencing circuit 5 provides a control pulse at the start of each transmitted pulse and this control pulse passes to a time delay circuit 11 which supplies a corresponding control pulse to switch on the amplifier 10 after a predetermined delay. The effect of the delay is to gate off the representative signal information that relates to objects positioned close to the transducers, such information producing relatively high voltage peaks in the signal from the filter 9. The sequencing circuit also provides a control signal at the end of each transmitted pulse which, after similar delay, switches off the amplifier 10. A typical output from the amplifier 10 is shown at C in Figure 2, the representative signal being gated off from time t_0 to t_3.

The signal from amplifier 10 is passed to a rectifier 12 and is then integrated by an integrator circuit 13. By gating off the initial part of each representative signal at the amplifier 10 the integrator is not saturated with high voltages in this part of the signal and accordingly can have high sensitivity.

The voltage which appears at the output of the integrator (shown at D in Figure 2) is fed to a comparator 14 and to a sample and hold circuit 15. The sample and hold circuit is controlled by the sequencing circuit so that at a given time the voltage from the sample and hold circuit is fed to the comparator and there compared with the voltage currently present at the output of the integrator. Immediately thereafter the sample and hold circuit is updated with the voltage then present at the output of the integrator and the integrator output voltage is zeroed by a signal on line 16 from the sequencing circuit. This comparison and zeroing is controlled so that it is carried out (e.g. at time t_4) before the end of the period (time t_2) which corresponds to the period in which the received signal has significant amplitude, so that the voltages that are used from the integrator are only those which result from reflections from objects within the required given range. By holding the integrator at zero during the remainder of the pulse period, voltages present at the output from rectifier 12 and representative of objects ...ge are ignored. If the voltage

from the sample and hold circuit differs from that at the output of the integrator by at least a fixed amount then the comparator 14 provides an output signal to an electronic switch 17 to a time-constant circuit 18. The electronic switch is timed from the sequencing circuit to be switched on for a brief fixed period after t_4, thereby adding charge to the time constant circuit if the comparator output is "high". If "high" comparator outputs occur continuously for a number of pulses the voltage at the output of the time-constant circuit will exceed the threshold voltage of a Schmitt trigger 19. The output of the trigger causes the alarm system 20 to be energised indicating significant movement in the protected area. If the rate of appearance of "high" comparator outputs is insufficient, the output of the time-constant-circuit will reach a quiescent level below the threshold of the trigger 19 and this low rate of detection will be ignored as being due to transient phenomena. Obviously the time-constant circuit would be omitted in situations where instantaneous detection of movement is required.

One of the facilities made possible by the use of the time-constant circuit 18 is the setting up and switching on of the system by an operator already present in the detection area. The delay due to the time-constant circuit 18 allows the operator to clear the detection area before the alarm operates. This is of value in, for example, the protection of an open sports car as the alarm system can be set from within the car by the driver and thus avoids the use of externally set switches which are liable to damage. In the context of open car protection a particularly suitable area for the mounting of the ultrasonic transmitter and receiver may be on the rear view mirror or on top of the dashboard. The alarm given, in this context may either be the sounding of the horn or other siren or flashing of the head lights or both.

It will be understood that the description relates only to one specific form of system and many modifications can be made to this. It has already been described how a time delay is applied to the amplifier 10 to prevent saturation of the integrator 13 by signals resulting from reflections from objects very close to the transducer. In some cases this may be disadvantageous and it may be necessary to monitor for movement within the whole of a given range. This can be achieved by, for example, replacing the integrator 13 by a delay line or digital memory with appropriate circuits to compare the detailed structure of successive representative signals. Alternatively, several integrators can be used in parallel, each integrator being controlled to be switched on during a period corresponding to one required part of the total range, the integrators between them covering the whole of the required range. Integrators can then be made of different sensitivity with the integrator corresponding to the area immediately in front of the transducers being the least sensitive. In place of the demodulator circuit described in the specific embodiment it is possible for very short range applications to use a simple envelope detector, the reflected pulse being mixed additively with dire

mitter to produce an amplitude modulated signal at the output of the receiving transducer. Other modifications will readily be apparent to those skilled in the art.

CLAIMS (filed on 10/2/83)

1. Movement detection apparatus comprising an ultrasonic transmitter, means for driving the transmitter to provide a series of pulses of ultra sound, an ultrasonic receiver positioned to receive reflected signals each being generated by impingement of a transmitted pulse upon objects lying within the beam area of the transmitted pulses, means to compare each transmitted pulse with the resulting reflected signal to provide a signal representative of phase differences between the two, means for limiting the duration of each representative signal so that this terminates before the end of the period which corresponds to the period of receipt of the reflected signal and means for utilising the representative signal to provide an output signal.

2. Apparatus according to claim 1 in which the duration of the representative signal is also limited by commencing that signal after the start of the period which corresponds to the period of receipt of the reflected signal.

3. Apparatus according to claim 1 or claim 2 in which the duration of each representative signal is effected by limiting the duration of that signal itself, the transmitted pulse and reflected signal being compared during the whole of the transmitted pulse period.

4. Apparatus according to claim 3 in which the or either duration limitation is effected after the representative signal has been passed through a band-pass filter.

5. Apparatus according to any one of the preceding claims in which the or either duration limitation is effected after the representative signal has been passed through a rectifier.

6. Apparatus according to claim 5 in which the or either duration limitation is effected after the rectified representative signal has been passed through an integrator.

7. Apparatus according to claim 3 in which the representative signal is passed through a band-pass filter, the earliest part of the information contained in the signal is suppressed, the signal containing the remainder of the information is amplified, rectified and integrated, the latest part of the information contained in the signal is suppressed, and the resulting form of the representative signal is utilised to provide the output signal.

8. Apparatus according to any one of the preceding claims in which the output signal is generated as a result of comparing two successive representative signals.

9. Apparatus according to claim 8 insofar as dependent on claim 7 in which the comparison is effected by a sample and hold circuit receiving said resulting form of the representative signal and comparing it with the previously received and held resulting form of the immediately preceding repre- ... erate an output signal propor-

tional to the difference between the two compared signals.

10. Apparatus according to claim 8 or claim 9 including means for adding output signals over a given period, means for comparing the total with a set value at the end of that period and means for operating an alarm if the total exceeds the set value.

11. Movement detection apparatus substantially as herein described with reference to Figure 1 of the accompanying drawings.

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